

Remarks

Claims 19-51 are pending in the Application.

Claims 19-51 stand rejected.

I. REJECTIONS UNDER 35 U.S.C § 103(a)

The Examiner has rejected Claims 19-51 under 35 U.S.C. § 103(a) as being unpatentable over Hamwi *et al.*, "Fluorination of Carbon Nanotubes," *Carbon*, **35**(6), 723-728 (1997) ("*Hamwi*") taken with Holloway *et al.*, "Fluorination of Buckminsterfullerene," *J. Chem. Soc., Chem. Commun.*, 966-969 (1991) ("*Holloway*"). Paper No. 10, at 2.

As noted in the Applicants' prior Amendment Under 37 C.F.R. § 1.111, filed May 23, 2003, ("Applicants' First 1.111 Amendment") (a) Claim 19, and Claims 20-25 which depend from it, are directed towards a method of derivatizing single-wall carbon nanotube sidewalls to bond fluorine to the sidewall of the nanotubes; and (b) Claims 26-51 all require single-wall carbon nanotubes that have fluorine covalently bonded to the sidewalls of the nanotubes.

A. Hamwi lacks limitations of the claims

Examiner asserts that *Hamwi* only differs from the current invention because it teaches fluorinating multi-wall carbon nanotubes, not single-wall carbon nanotubes. Paper No. 10, at 2.

As noted in Applicants' First 1.111 Amendment at 7-8, the significance of this distinction between multi- and single-wall carbon nanotubes is accounted for in detail, particularly with regard to the chemical and physical differences between single-wall carbon nanotubes and multi-wall carbon nanotubes. Furthermore, Examiner's assertion appears to ignore that *Hamwi* does not disclose the bonding of fluorine to the sidewalls of the carbon nanotubes, which is a requirement of each of the present claims.

Hamwi discloses fluorinating multi-wall carbon nanotubes under two conditions: (1) with a mixture of F₂, IF₅, and HF at room temperature; and (2) with pure F₂ at about 500°C. *Hamwi* considered only these two conditions, neither of which was effective for nanotube fluorination, and did not investigate a range of temperatures between about room temperature and about 500°C.

Hamwi's attempt to fluorinate multi-wall carbon nanotubes at room temperature did not result in bonding to the nanotube sidewall. *Hamwi* produced intercalation compounds in which fluorine resides between the nanotubes. *Hamwi* concluded that "fluorine-nanotube intercalation compounds, CF_x , were formed with nevertheless a limited fluorination degree with $x \leq 0.4$. The exact structure of these compounds is not yet fully known and more detailed studies are being undertaken." (*Hamwi*, p. 728, col. 1. para. 1.)

Hamwi's attempt to fluorinate multi-wall carbon nanotubes at high temperatures was also ineffective. Fluorination at about 500°C destroyed the nanotubes and resulted in amorphous fluorinated carbon. *Hamwi's* TEM results indicated, "the tubular structure disappeared, the overall diameter increased, no central channel was observed and the aromatic layers disappeared, proving the existence of amorphous fluorinated carbon." (*Hamwi*, p. 727, col. 1, para. 2 to col. 2. para. 1.) *Hamwi* further concluded that "Fluorination reactions at high temperature destroyed the nanotube structure," (*Hamwi*, p. 728, col. 1. para. 1.)

Neither attempt by *Hamwi* produced a product analogous to that of the present invention wherein the fluorine is covalently bonded to the side-wall of a single-wall carbon nanotube. Thus, there is no reasonable expectation of success in using the *Hamwi* process on single-wall carbon nanotubes to produce single-wall carbon nanotubes with fluorine bonded to the sidewalls of the nanotubes. To the contrary, *Hamwi* teaches away from the claimed invention by teaching fluorination in temperature regimes in which Applicants has shown their invention to be unachievable.

B. Examiner's Official Notice Is Insufficient

The Examiner takes Official Notice that claimed fluorinating agents are old and known as fluorinating agents and that single-wall carbon nanotubes are also old and known. Paper No. 10, at 2. The Examiner then relies upon these facts as a basis for suggesting that it would have been obvious to utilize single-wall carbon nanotubes in the process of *Hamwi*. The Examiner's reliance on the noticed facts is misplaced, in that nothing in these facts suggests that utilizing a fluorinating agent with single-wall carbon nanotubes would yield carbon nanotubes with fluorine bonded to the sidewalls of the nanotubes.

A *prima facie* showing of obviousness requires, *inter alia*, that there be a reasonable expectation of success in combining or modifying the teachings of a reference to make the claimed invention. MPEP § 2143. Moreover, the expectation of success must be found in the teachings of the reference itself. *Id.* As discussed above, this cannot be suggested in *Hamwi*, as *Hamwi* neither discloses single-wall carbon nanotubes nor discloses bonding of fluorine to the sidewall of a single-wall carbon nanotube. The Official Notice cannot fill this gap. Single-wall carbon nanotubes do not react significantly with fluorine at room temperature and they are destroyed by a reaction with fluorine at 500°C; thus, there is no expectation of success in producing fluorinated single-wall carbon nanotubes as claimed in the Application by applying the process described by *Hamwi* to single-wall carbon nanotubes.

C. Holloway Is Similarly Insufficient

Holloway is directed to C₆₀, not single-wall carbon nanotubes. While single-wall carbon nanotubes differ markedly from multi-wall carbon nanotubes (as outlined in Applicants' First 1.111 Amendment, at 7-8), single-wall carbon nanotubes are also significantly different from C₆₀ in numerous aspects, including, but not limited to, structure, reactivity and properties.

Single-wall carbon nanotubes are hollow, tubular fullerene molecules of carbon atoms typically arranged in hexagons and pentagons on their ends and in hexagons along their sidewalls. Single-wall carbon nanotubes are variable in size and have high aspect ratios, with diameters typically in the range of about 0.5 nm and about 3.5 nm, and lengths usually greater than about 50 nm. Single-wall carbon nanotubes in bulk form tend to bundle or "rope" along their long axes and tend to be tightly held together by van der Waals forces.

In contrast, C₆₀ is a distinct, uniform molecular species with 60 carbon atoms in spherical arrangement with 20 hexagons and 12 pentagons. The pentagons in C₆₀ are highly strained sp² carbons and contribute to C₆₀'s high reactivity. The sidewall of carbon nanotubes is a uniform layer of hexagonally-bonded carbon. This form of carbon is similar to the basal plane of graphite and is relatively chemically inert. C₆₀ is missing the element of a sidewall of hexagonally-bonded carbon that is present in single-wall carbon nanotubes. As the present

claims are directed to bonding fluorine on the sidewall of the carbon nanotubes, the lack of such a sidewall is a substantial difference that causes the comparison to be misplaced.

As in *Hamwi*, *Holloway* attempts fluorination at low temperature (*i.e.*, 70°C), whereas Applicants observed little or no fluorination of single-wall carbon nanotubes at temperatures as high as 150°C.

Again, there is no suggestion in *Holloway* or *Hamwi* (taken either alone or in combination) to use single-wall carbon nanotubes in any of the processes disclosed in these references. And, even had this been done, the processes would not have resulted in single-wall carbon nanotubes having fluorine bonded to the sidewalls of the nanotubes. And, since fluorinated single-wall carbon nanotubes as claimed in the Application would not have resulted, there cannot be any expectation of success by applying the process described by *Hamwi* and/or *Holloway* to single-wall carbon nanotubes.

As such each of Claims 19-51 is not obvious, and Applicants respectfully request the Examiner to withdraw these rejections for these reasons and the reasons presented in Applicants' First 1.111 Amendment.

D. Secondary Considerations Regarding Nonobviousness of the Claimed Invention

While the above shows the nonobviousness of Applicants' invention, objective evidence further supports the nonobviousness of the claimed invention. Objective evidence, composed of real world facts, is worthy of great weight. *Rosemount, Inc. v. Beckman Instruments, Inc.*, 727 F.2d 1540, 1546, 221 U.S.P.Q. 1, 7 (Fed. Cir. 1984). Such indicia of nonobviousness include widespread recognition of the invention's significance in the industry. *Id.*

As a testament to the uniqueness and nonobviousness of this claimed invention over the existing prior art, the Examiner is asked to consider that Holzinger *et al.*, "Sidewall Functionalization of Carbon Nanotubes," *Angew. Chem. Int. Ed.*, **2001**, *40*, 4002-4005 ("*Holzinger*," attached hereto at Exhibit A) reported that Applicants' work involving fluorination with optional subsequent nucleophilic substitution was one of only two techniques capable of functionalizing (derivatizing) the sidewall of the single-wall carbon nanotube. (The

other technique is a later invention disclosed in International Publication No. WO 02/060812 by Tour, *et al.*, filed January 29, 2002, which is commonly assigned to the assignee of the present Application.)

Furthermore, the Applicants' work relating to the claimed invention has been cited numerous times in the open literature. See Exhibit B for a Scientific Citation Index report for this work showing 320 citations to date.¹

As another testament to the uniqueness and nonobviousness of this claimed invention over the existing prior art, the Examiner is asked to note that the claimed invention, having entered the marketplace in 2002, was a winner of one of *R&D Magazine's* 2003 R&D 100 Awards for being one of the 100 most technologically significant products or processes that entered the marketplace over the past year. See Exhibit C (excerpts from the *R&D Magazine*, September 2003 publication, which on page 48 refers to Applicants' award winning invention as a "New Class of Nanomaterials.")

"Praise for the invention, including awards accorded to the inventors for their invention, is further evidence of the novelty and worth of the inventions." *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 671 F. Supp. 1369, 1398, 5 U.S.P.Q.2d 1545, 1569 (S.D.N.Y. 1987) (citing *Rosemount*, 727 F.2d at 1546, 221 U.S.P.Q. at 7), *aff'd*, 868 F.2d 1251, 9 U.S.P.Q.2d 1962 (Fed. Cir. 1989); see also *Polysius Corp. v. Fuller Co.*, 709 F. Supp. 560, 573, 10 U.S.P.Q.2d 1417, 1426 (E.D. Pa.), *aff'd mem.*, 889 F.2d 1100 (Fed. Cir. 1989).

The Applicants respectfully assert that this objective evidence further substantiates the nonobviousness of Applicant's invention.

Applicants respectively remind the Examiner that when objective evidence of nonobviousness is properly presented, this evidence must be considered. *In re Sernaker*, 702 F.2d 989, 996, 217 U.S.P.Q. 1, 7 (Fed. Cir. 1983). Moreover, such evidence can "often serve as insurance against the insidious attraction of the siren hindsight" when evaluating the prior

¹ Applicants' publications respecting the invention of the present Application included: (1) Mickelson *et al.* "Fluorination of Single-Wall Carbon Nanotubes," *Chem. Phys. Lett.*, 296 (1-2): 188-194 (October 1998); (2) Mickelson *et al.* "Solvation of Fluorinated Single-Wall Carbon Nanotubes In Alcohol Solvents," *Journal of Phys. Chem. B*, 103(21):4318-4322 (May 1999); and (3) Mickelson *et al.* "Reversible Sidewall Functionalization of Buckytubes," *Chem. Phys. Lett.*, 310 (3-4): 367-372 (September 1999). As reflected in Exhibit B, these three publications were respectively cited 121, 83, and 116 times in the open literature. See Exhibit B.

art. *W. L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1553, 220 U.S.P.Q. 303, 313 (Fed. Cir. 1983).

As a result of the foregoing, it is asserted by Applicants that the Claims in the Present Application are in condition for allowance, and respectfully request allowance of such Claims.

Applicants believe that no further fees are due. However, the Director is Authorized to debit any amounts due by this paper to Deposit Account No. 23-2426 of Winstead Sechrest & Minick P.C.

Applicants respectfully request that Applicants' attorney be called at the below listed number if should there be any questions related to this matter.

Respectfully submitted,

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